Computational fluid dynamic analysis of concentration polarization and water flux optimization in spiral wound modules

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Computational fluid dynamics analysis of concentration polarization and water flux optimization in spiral wound modules

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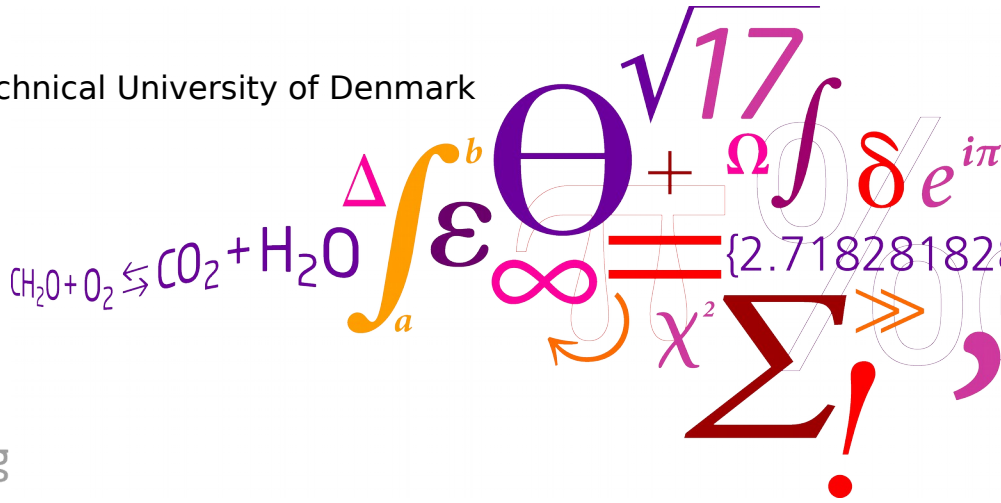
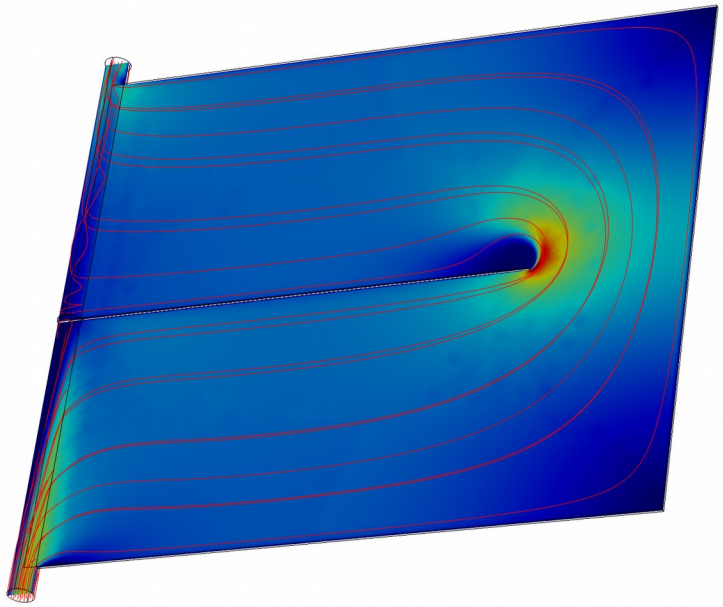
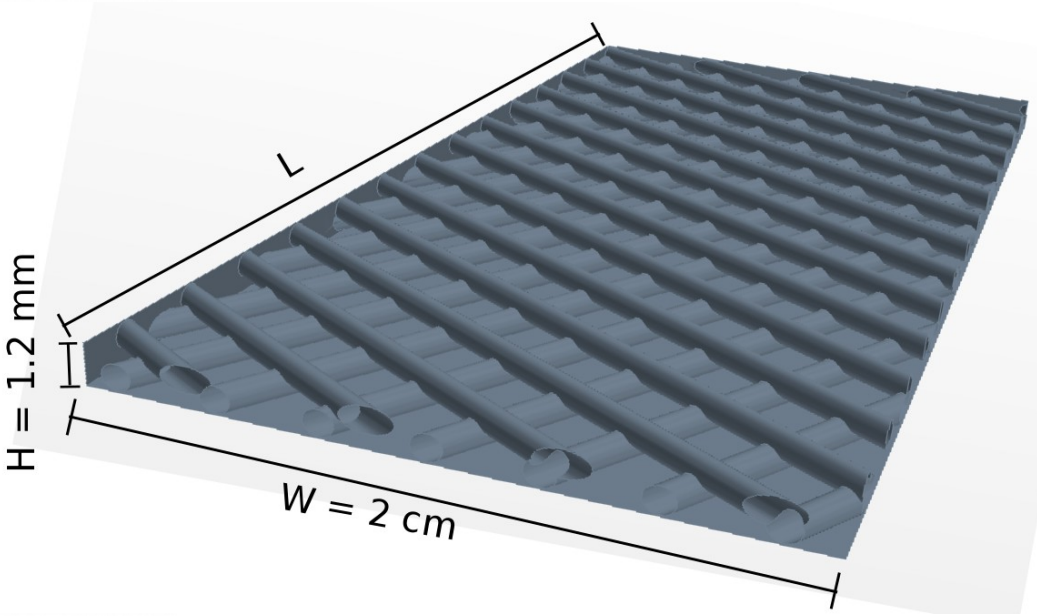


DTU Environment
Department of Environmental Engineering

Investigation of the number of envelopes for FO-SWM



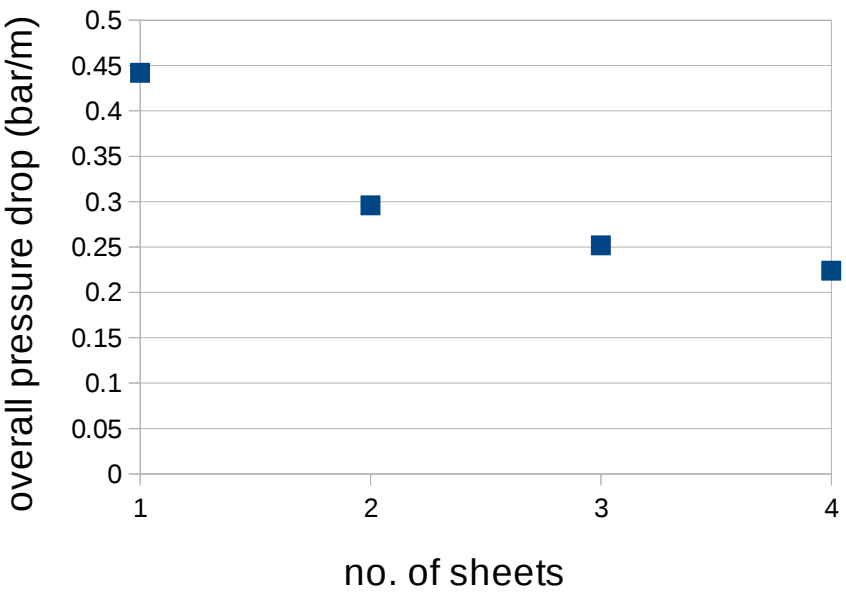


- A baffle inside the inner tube and the envelopes, forces the respective solution to flow around the baffle tip.
- The inhomogeneous flow field causes severe ECP.

- Investigation of pressure drop in FO-SWM configuration
- Spacer similar to Conwed '46 Mils' RO spacer: D = 2.55mm; H = 1.17mm

Investigation of the number of envelopes for FO-SWM

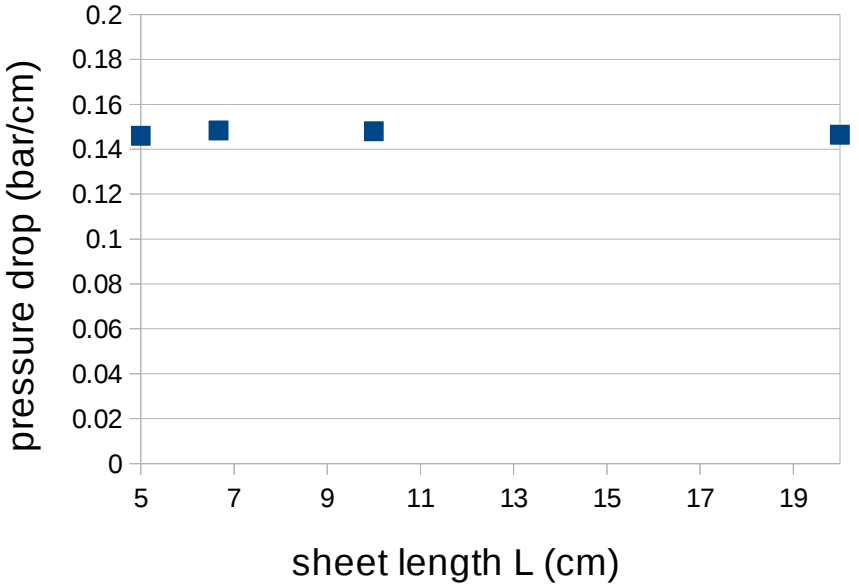
1. The overall pressure drop get smaller with the number of sheets, due to the reduced cross flow velocity.



1. Fixed feed flow rate 1.26 e-2 m^3/s

$$\frac{\Delta p}{L} = \mathcal{O}(U_{cross}^2)$$

2. The pressure drop along a sheet is constant.

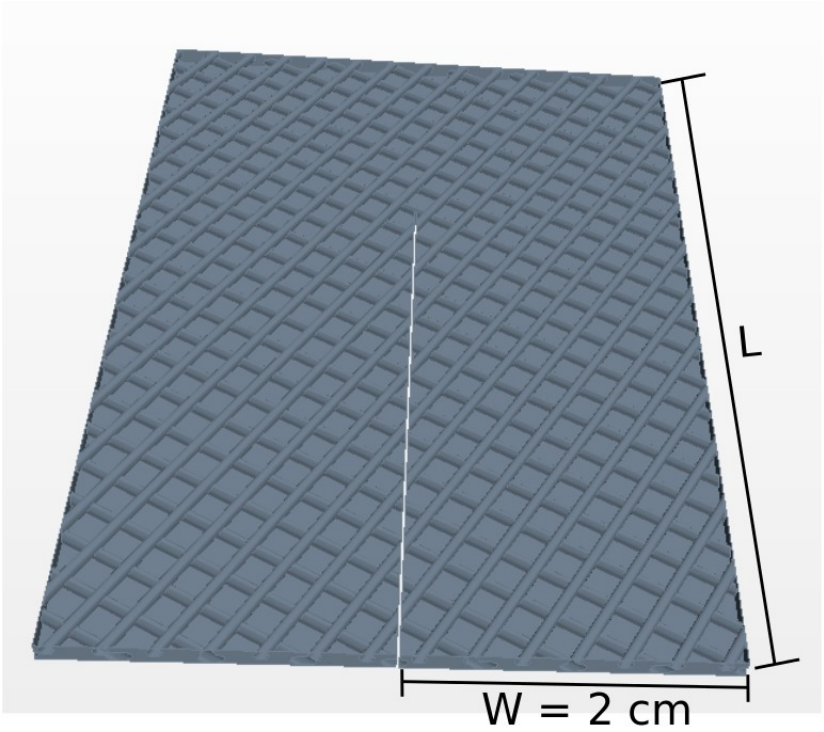


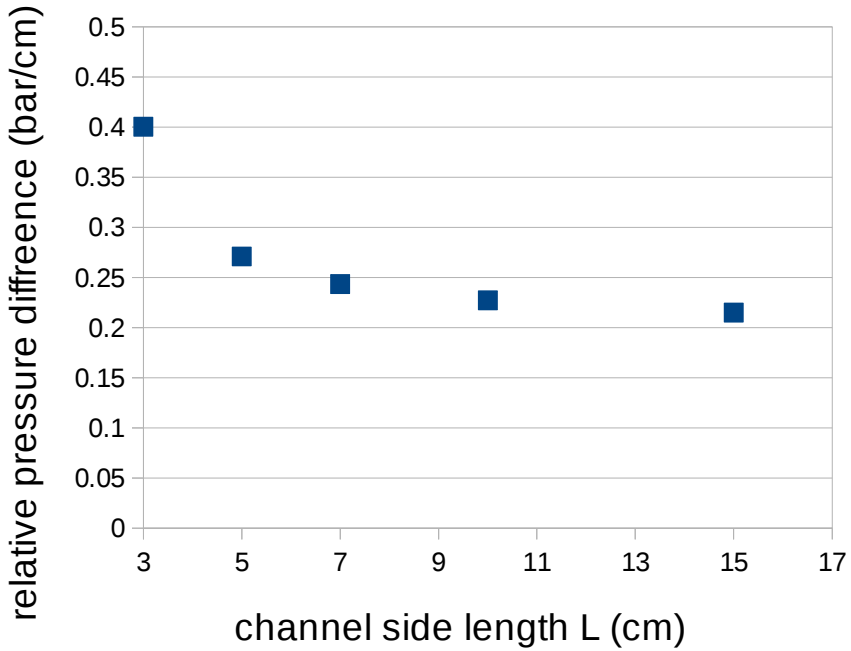
2. Fixed cross flow velocity 10 cm/s

$$\Delta p \sim L$$

Investigation of the number of envelopes for FO-SWM

1. While keeping the cross flow velocity constant, the pressure difference divided by the side length (relative pressure difference) is not constant.





Fixed cross flow velocity 10 cm/s

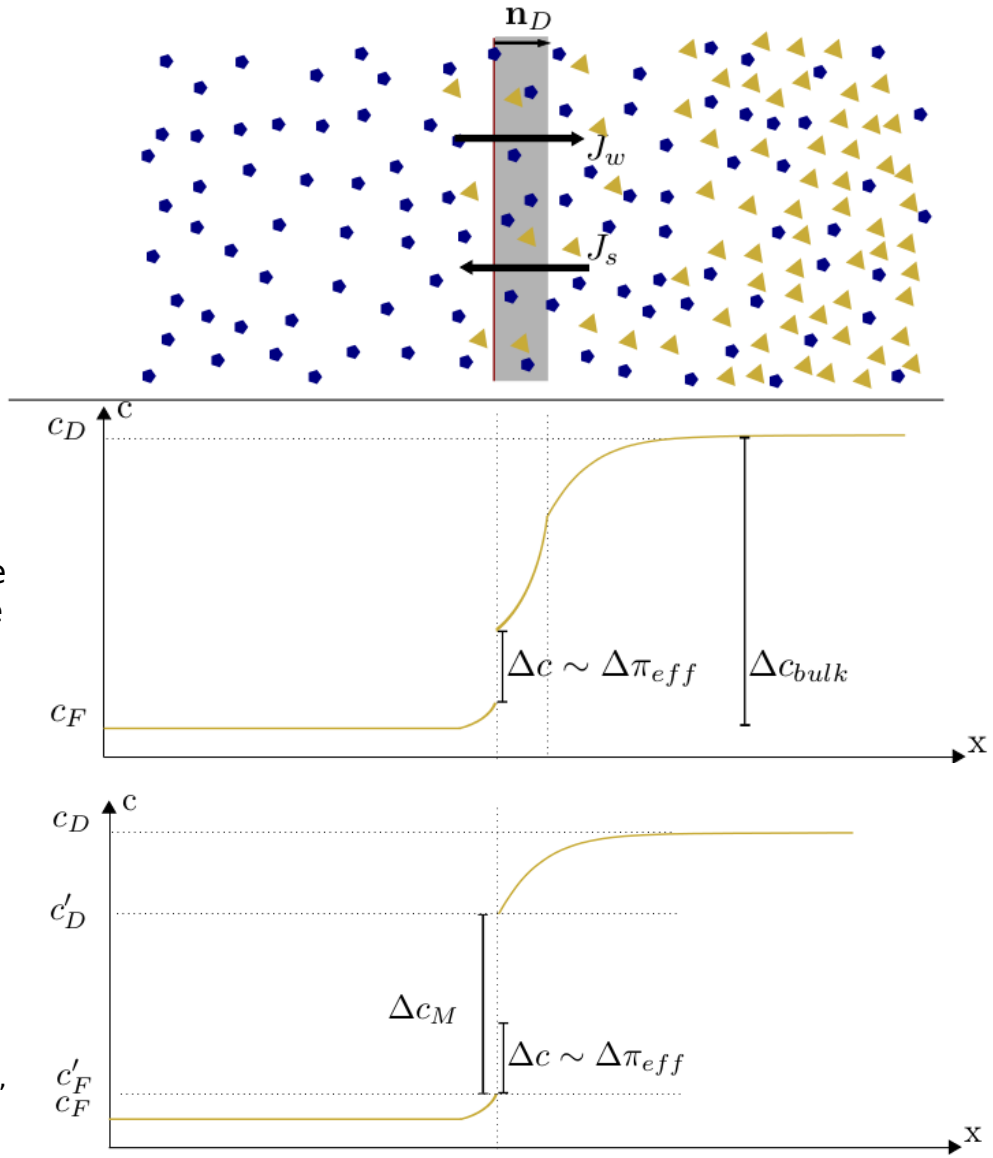
→ The number of membrane envelopes in FO-SWM matters.

The membraneFOAM algorithm

OpenFOAM algorithm resembling FO processes:

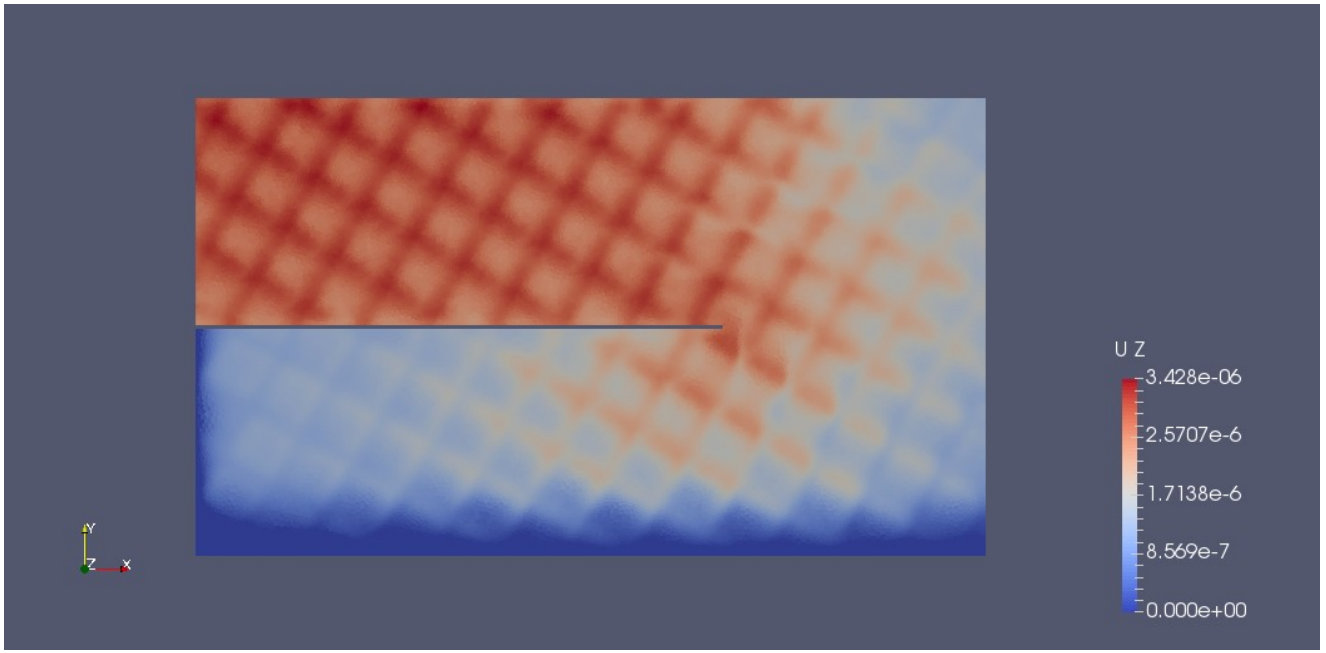
- Modelling ICP, depending only on A,B,K
- Evaluating the consequent water and reverse salt fluxes
- Developed in (1)
- Modification include applicability to bent membrane surfaces and non-zero hydraulic pressure difference across membrane

$$\mathbf{J}_w = A \left[\frac{\pi_F |\mathbf{J}_W| \left[\frac{c_D}{c_F} - exp(|\mathbf{J}_w| K) \right]}{(|\mathbf{J}_w| + B)\, exp(|\mathbf{J}_w| K) - B} - \Delta p \right] \mathbf{n}_D$$



(1) Gruber et al. Journal of Membrane Science, Vol. 379, No. 1-2, 2011, p. 488-495

Mapping the water flux – optimization of spacer and baffle geometry



The water flux map allows to spot zones of severe ECP:

- When the optimal spacer and baffle geometry is found, the optimization process is brought to the pressure optimization and the number of envelopes.

Thank you for your attention!

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In the near future:

- Baffle design
- Curvature influence
- PRO-SWM

Bullet points

- Motivation
- What we do
- Spacer optimization
- Envelop sheets
- FO SWM
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